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ABSTRACT

This paper reports the results of a study of the development of an innovative learning element designed to be implemented in a computer-facilitated learning (CFL) module. The learning element is an open-ended, short answer, text question tool (TQT) designed to be used in World Wide Web-based courses or incorporated into hybrid Web/CD-ROM systems. The TQT object facilitates the development of extended question-and-answer problems which overcome the limitations of multiple choice question format. The TQT facilitates an iterative approach to developing student knowledge constructions. The examples provided in this paper relate to questions developed for the Department of Anatomy, Faculty of Medicine at the University of Melbourne (Australia). However, it is stressed that the TQT is applicable to many other academic disciplines with similar needs to develop student understanding of specific content domains. Topics addressed include functional aspects of the TQT, the TQT and student learning, and current development and evaluation. Three figures illustrate the structural view of the TQT, a functional view of the TQT object, and the prototype of the TQT; one table presents an example proforma for anatomy questions. (Author/DLS)

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An Open-ended, Short Answer, Text Question Tool: Improving Interactivity on the Web

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Abstract: This paper reports the results of a study of the development of an innovative learning element designed to be implemented in a computer-facilitated learning (CFL) module. The learning element is an open-ended, short answer, text question tool (TQT) designed to be used in Web-based courses or incorporated into hybrid Web/CD-ROM systems. The TQT object facilitates the development of extended question-and-answer problems which overcome the limitations of the multiple choice question format. The TQT facilitates an iterative approach to developing student knowledge constructions of knowledge. The examples provided in this paper relate to questions developed for the Department of Anatomy, Faculty of Medicine at The University of Melbourne. However, it must be stressed that the TQT is applicable to many other academic disciplines with similar needs to develop student understanding of specific content domains.

Introduction

The development of the Text Question Tool (TQT) is an additional component of the Learning Engines project—work being undertaken by the Multimedia Education Unit (MEU) at The University of Melbourne to develop simple Web-based learning tools [Fritze & McTigue 1997]. The project is developing a number of generic learning tools for the implementation of Web-based, CD-ROM or Web/CD-ROM hybrid course materials. A number of these tools have already been produced including an a concept mapping tool, tutorial item set tool, and an interactive graphing tool [Kennedy, Fritze, & McTigue, 1997]. The Text Question Tool is designed to be a generic question tool which facilitates the construction of computer-facilitated learning (CFL) modules or Web-based courses. The functional aspects of the TQT are the:

- facility to allow students to type in short text-based answers in a field in a Web page based upon a question item;
- ability of the TQT to search for key words or phrases defined by the lecturer;
- ability to provide feedback to students based upon the number of key words or phrases found in the text string typed in by the student; and
- facility to respond to student requests for Hints, spelling of terms, and expert answers to the question.

Faculty members from the departments of Chemistry, Physics, Anatomy, Pharmacology and Economics at The University of Melbourne were surveyed to determine the needs of delivering on-line tutorials. While the needs of each academic discipline were varied, the TQT was perceived to be fundamental to the implementation of Web-based courses. The department of Anatomy is participating in the development, design and the formative evaluation of the TQT. The design of cognitive tools for student learning is an outcome of a theoretical framework developed to link what is known about sound educational practice with the design of interactive elements to incorporate into multimedia courseware [Kennedy, Fritze, & McTigue, 1997; Kennedy & McNaught, 1997].

The Text Question Tool and Student Learning

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The TQT fulfils a number of educational requirements not available in current Web-based courseware tools. These are:

- allowing a student to express more complex concepts and ideas *in her or his own words* and receive immediate feedback in a Web-based environment;
- providing an environment in which students can refine and reflect upon their understanding of concepts which is non-threatening;
- allowing the content expert to decide the content matter and the appropriate form and language of the answer. It is the lecturer who decides the key words, hints and expert answers pertinent to a particular content domain; and
- providing an opportunity for students to learn in an environment which is supported by a sound educational framework.

A non-functional example of the look-and-feel of the TQT object with examples of questions may be found at <http://www3.meu.unimelb.edu.au/meuweb/staff/dkennedy/TQT.html>. The TQT has been through a number of iterations in discussions with academic staff from the department of Anatomy using the scenario-based approach. Scenarios have been chosen because they "are grounded in the work activities of prospective users; the work users do drives the development of the system intended to augment this work. Thus scenarios are often open-ended and fragmentary; they help developers and users pose new questions, question new answers, open up possibilities" [Carroll 1995], p. 5.

Example of a scenario in Anatomy: The student reads a question—in conjunction with an range of resources (e.g., an series of anatomical images, a video clip of the initial phases of the proceedure, or images of the radiological perspective) from the lower back in the Interactive Anatomy (IA) database—and is required to link the procedure with the underlying anatomical structures. For example, the insertion of a needle for a lumbar puncture requires an understanding of the anatomical structures the needle must pass through, the angle of insertion, and how far the needle must be inserted in order to obtain cerebrospinal fluid. The student is required to apply her or his anatomical knowledge in order to solve a clinical problem—which determines the success or failure of this procedure.

Teaching and learning

The advent of the World Wide Web (Web) and the shift to delivery of courses via the Web has provided the impetus to develop pedagogically sound learning tools for student learning. It has become clear that merely placing lecture notes on the Web is not sufficient for student learning to occur. However, there is a lack of suitable interactive learning tools which are Web compatible to actively engage the learner. A major purpose of any learning tool should be to provide teachers and lecturers with the facility to match the desired educational outcomes of a Web-based course with the learning elements which have the greatest potential to achieve those outcomes. For example, studies from many institutions over a period of many years "have drawn attention to the wide gap between the rhetoric describing the qualities lecturers say they want in their students' responses, and the tasks they set" [Biggs 1989], p. 15—however, the on-line learning tools which actively engage students are currently very limited. The TQT is potentially one such tool. A general schematic view of the TQT is shown in [Fig. 1].

In the Interactive Anatomy project the TQT will be used to:

- develop the ability to analyse clinical problems by utilising students' knowledge of anatomical structures,
- link procedural knowledge with anatomical knowledge, and
- promote active learning.

In addition the TQT can be utilised in this project and other academic disciplines to:

- provide a mechanism for self-assessment,
- develop procedural knowledge, and
- facilitate the development of descriptive terminology.

There are a number of components in the TQT environment They include:

- a field into which the student can type an answer to a question,
- the hints assigned by the lecturer,
- the spelling helper,
- the expert answers, and
- the facility to print a record of a students' responses and self-assessment to disk for later review (by the student).

Student Learning

Learning is the way in which an individual changes the way s/he conceptualises the world. *Teaching* involves a lecturer constructing learning opportunities for students. One of the major difficulties in the design of computer-facilitated learning (CFL) is the gulf between the instructional or educational design of CFL and what the research literature indicates is good teaching practice [Ramsden 1992]. There is considerable evidence that students need to be actively engaged in knowledge construction through a variety of learning experiences [Laurillard 1993]. The need to make learning environments as rich as possible to enhance students' ability to construct knowledge and resolve conceptual difficulties is fundamental if courseware is to be a significant part of course delivery in the next 10 years. Only limited examples exist where CFL has replaced part of the traditional approach to academic learning in higher education. At present there are very few learning tools of the type being developed by the MEU (Learning Engines, [Fritze, & McTigue 1997]) available for lecturers to construct learning opportunities which actively engage students. The self-assessment component of the TQT is one valid method of determining the 'distance' between the student response and the expert answers provided by the content expert.

The TQT is not intended to:

- supplant conventional examinations (formal assessment) although it may be possible to do so in the future,
- address syntax, grammar or content other than in a very fundamental way (key words), or
- address open-ended essay type questions.

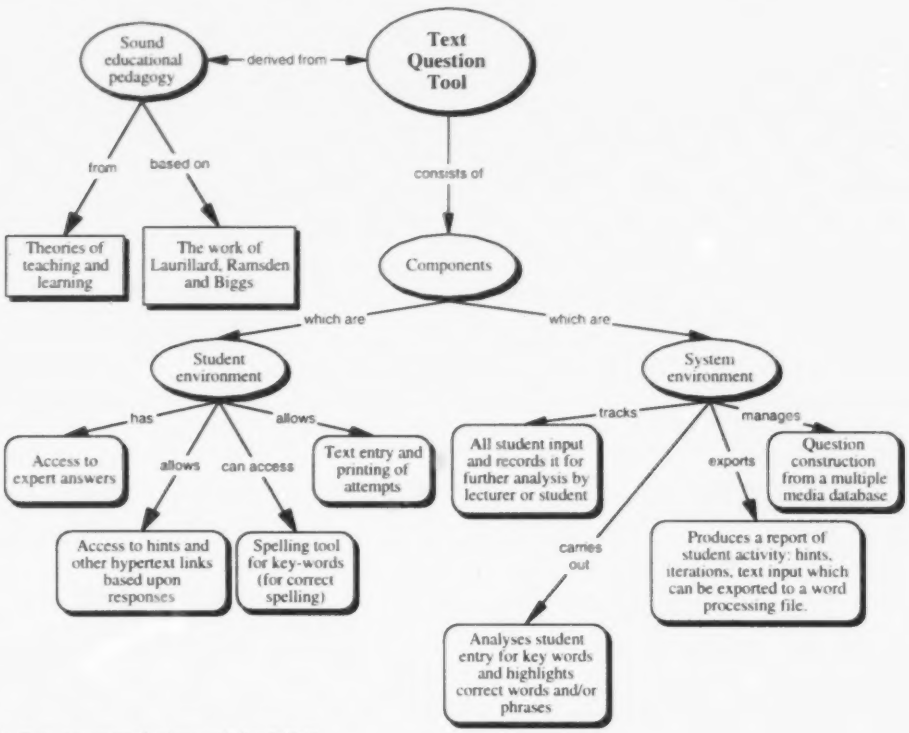
Sound educational pedagogy
derived from
Text Question Tool
from
based on
consists of
Theories of teaching and learning
The work of Laurillard, Ramsden and Biggs
Components
which are
which are
Student environment
System environment
has
allows
tracks
manages
Access to expert answers
allows
can access
Text entry and printing of attempts
All student input and records it for further analysis by lecturer or student
exports
Question construction from a multiple media database
Access to hints and other hypertext links based upon responses
Spelling tool for key-words (for correct spelling)
carries out
Produces a report of student activity: hints, iterations, text input which can be exported to a word processing file.
Analyses student entry for key words and highlights correct words and/or phrases

Figure 1: The structural view of the TQT

A Functional View of the TQT

A functional view of the current iteration of the TQT object is shown in [Fig. 2]. The structure of the authoring environment is critical as the tool is to be used by lecturers with limited computing experience. Design of the authoring environment is guided by work carried out as part of Learning Engines Project. A key component of the intended authoring environment is the ability to incorporate graphics, animations etc., as

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sources of question objects. Currently, the functionality of the TQT is linked to a database. The lecturers have a proforma which sets the:

- the key words, spelling terms, expert answers, and hints for students; and
- structuring of questions with multiple forms of media (video and images from the Interactive Anatomy database).

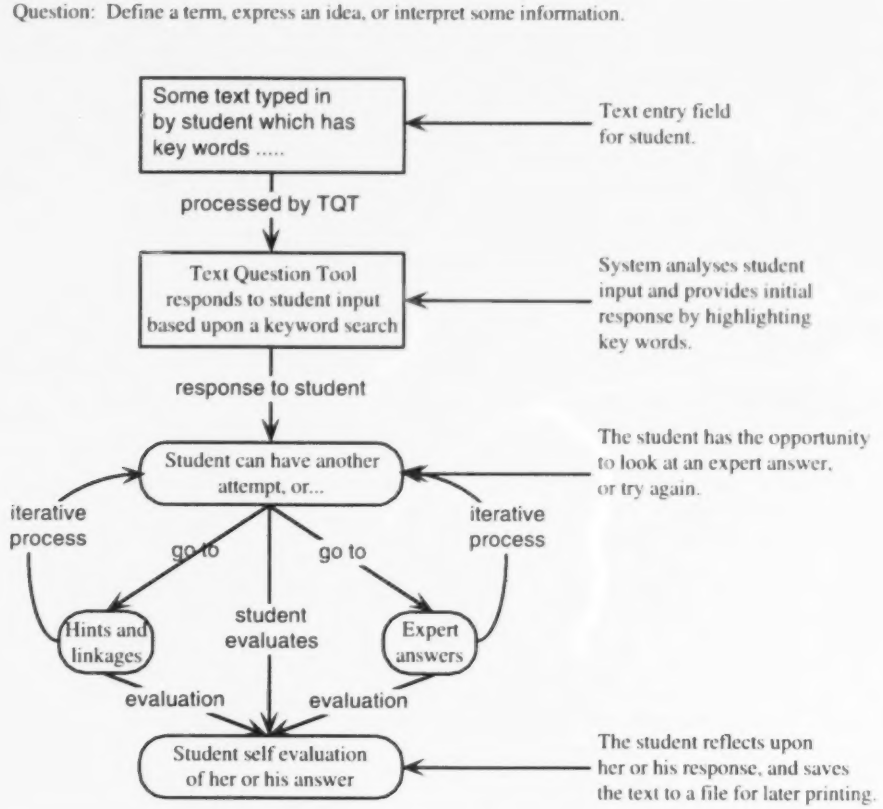
Question: Define a term, express an idea, or interpret some information.
Some text typed in by student which has key words .....
Text entry field for student.
processed by TQT
Text Question Tool responds to student input based upon a keyword search
System analyses student input and provides initial response by highlighting key words.
response to student
Student can have another attempt, or...
The student has the opportunity to look at an expert answer, or try again.
iterative process
iterative process
go to
go to
Hints and linkages
student evaluates
Expert answers
evaluation
evaluation
Student self evaluation of her or his answer
The student reflects upon her or his response, and saves the text to a file for later printing.

Figure 2: A functional view of the TQT object

Current Development and Evaluation

Preliminary work on the TQT has been completed. The development of the TQT is focused on the Interactive Anatomy project currently nearing the end of its first of two years in the Medical Faculty. The first 8 of 16 PhotoCD disks have been completed. Currently the design team is developing the first two modules for use with students in 1999. The TQT will be incorporated into interactive tutorials on CD-ROM which will facilitate the development of anatomical knowledge in a case-based clinical approach. Student evaluations of the modules will take place in early 1999. A screen capture of the prototype is shown in [Fig. 3].

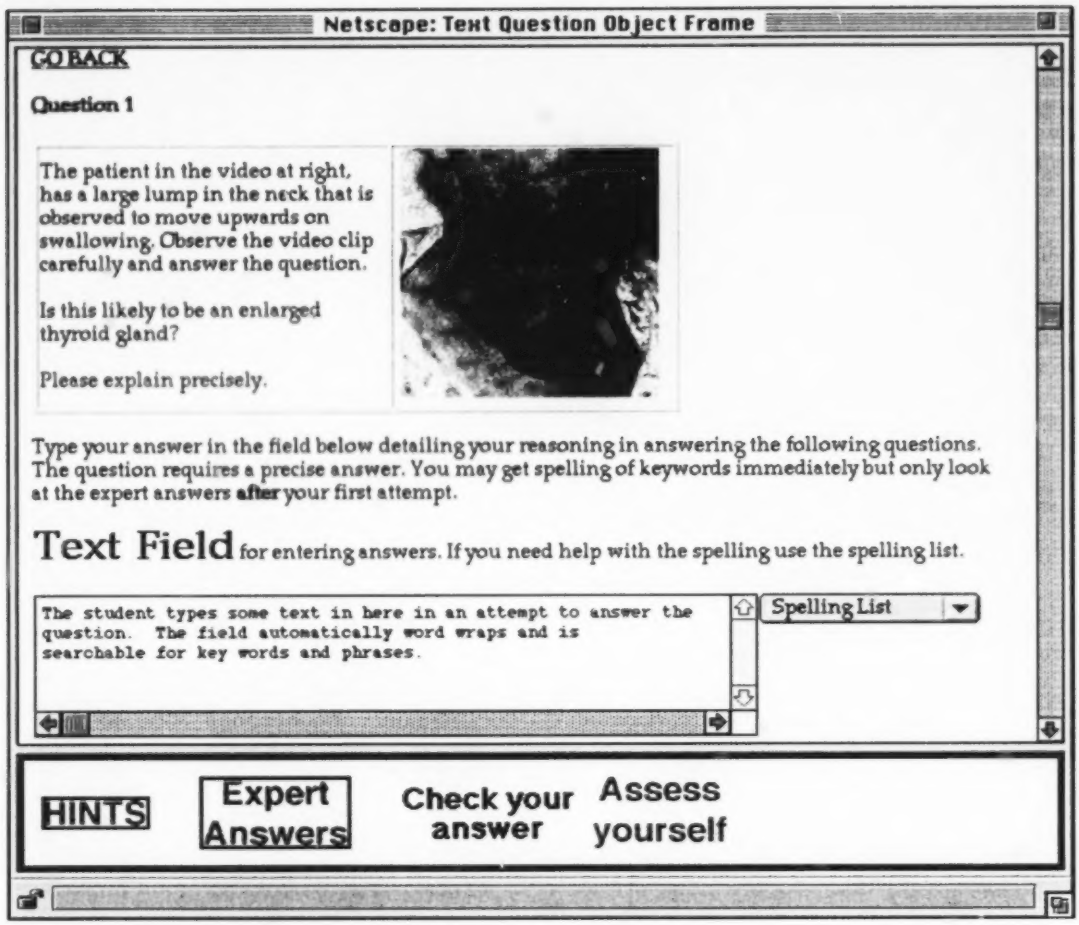
Netscape: Text Question Object Frame
GO BACK
Question 1
The patient in the video at right, has a large lump in the neck that is observed to move upwards on swallowing. Observe the video clip carefully and answer the question.
Is this likely to be an enlarged thyroid gland?
Please explain precisely.
Type your answer in the field below detailing your reasoning in answering the following questions. The question requires a precise answer. You may get spelling of keywords immediately but only look at the expert answers after your first attempt.
Text Field for entering answers. If you need help with the spelling use the spelling list.
The student types some text in here in an attempt to answer the question. The field automatically word wraps and is searchable for key words and phrases.
Spelling List
HINTS
Expert Answers
Check your answer
Assess yourself

Figure 3: Prototype of the Text Question Tool

Sample Questions and Answers from the Interactive Anatomy Project

The Interactive Anatomy CD-ROM project is a large interactive multimedia project at the end of its first year which is part of the restructuring of the curriculum in the Medical Faculty. In each question the student would be told to type her or his answer in the text entry field to answer the question. Information in the *Help* section for the student will include:
"These are technical questions requiring technical answers. You may get hints of keywords, check your spelling in the Spelling Tool or look at the expert answers after your first attempt. Once you have reached a decision, check your answer against the expert answer(s). You will be told how many of the key words or phrases you have entered which are appropriate to the question. You may try again if not satisfied or check your answer against the expert answer(s) provided and estimate your mark. These results can be saved to disk and printed out later."

Two example questions are shown in [Tab. 1].

Summary

This project differs from the investigations into artificial intelligence and full text recognition and analysis of text by computers in a number of important ways. Firstly, it is not intended that the TQT would be semantically coherent, that is, be able to analyse a student response as an experienced teacher of the subject matter. There is

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considerable evidence (discussed earlier) that this level of complexity is not required in order to significantly enhance student learning. The second major difference is the assessment of student answers. The students are expected to assess their own answers and provide a mark or grade for their future reference. In the future it may be possible to construct a basic marking algorithm based upon the number of key words or phrases used; however, this is not perceived to be an educational requirement—students can learn without formal assessment. The TQT is an interactive learning tool which has the potential to enhance student learning.

Year	Question	Expert answer	Keywords and/or phrases
First Year Anatomy	The patient in the photograph, has a large lump in the neck that is observed to move upwards on swallowing. Is this likely to be an enlarged thyroid gland? Please explain precisely [Fig. 3].	It is in the midline and the thyroid gland moves on swallowing as it is in the pretracheal fascia which attaches to the oblique line of the thyroid cartilage (of the larynx).	pretracheal fascia, oblique, thyroid cartilage, larynx, midline
Second Year Anatomy	Explain the difference between a direct inguinal hernia and an indirect inguinal hernia?	A direct hernia pushes through a weakness in the posterior wall of the inguinal canal and is found medial to the inferior epigastre artery. An indirect hernia exits the abdominal cavity via the deep inguinal ring into the inguinal canal and is lateral to the inferior epigastric artery.	medial, lateral, inferior epigastric artery, inguinal canal, posterial wall, deep inguinal ring

Table 1: Example proforma for anatomy questions

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